# ACOUSTIC TOUCH SENSOR WITH LOW-PROFILE DIFFRACTIVE GRATING TRANSDUCER ASSEMBLY

## CROSS-REFERENCE TO RELATED APPLICATIONS

**[0001]** This application is a continuation of copending, commonly assigned U.S. application Ser. No. 10/603,514, filed Jun. 24, 2003, the disclosure of which is incorporated herein by reference.

## FIELD OF THE INVENTION

**[0002]** The field of the present invention relates to touch sensor technology, and more particularly to acoustic touch sensor technology.

## BACKGROUND OF THE INVENTION

**[0003]** Touch sensors are transparent or opaque input devices for computers and other electronic systems. As the name suggests, touch sensors are activated by touch, either from a user's finger, or a stylus or some other device. A transparent touch sensor, and specifically a touchscreen, is used in conjunction with a display device, such as cathode ray tube (CRT), liquid crystal display (LCD), plasma, electroluminescent, or other type of display, to form a touch display. These touch displays are increasingly used in commercial applications, such as restaurant order entry systems, industrial process control applications, interactive museum exhibits, public information kiosks, pagers, cellular phones, personal digital assistants, and video games.

**[0004]** The dominant touch technologies presently in use are resistive, capacitive, infrared, and acoustic technologies. Touchscreens incorporating these technologies have delivered high standards of performance at competitive prices. All are transparent devices that respond to a touch by transmitting the touch position coordinates to a host computer. Acoustic touchscreens, also known as ultrasonic touchscreens, have competed effectively with these other touch technologies. This is due in large part to the ability of acoustic touchscreens to handle demanding applications with high transparency and high resolution touch performance, while providing a durable touch surface.

**[0005]** Typically, an acoustic touchscreen comprises a touch sensitive substrate in which an acoustic wave is propagated. When a touch occurs on the substrate surface, it results in the absorption of at least a portion of the wave energy being propagated across the substrate. The touch position is determined using electronic circuitry to locate the absorption position in an XY coordinate system that is conceptually and invisibly superimposed onto the touchscreen. In essence, this is accomplished by recording the time the wave is initially propagated and the time at which a touch induced attenuation in the amplitude of the wave occurs. The difference in these times can then be used, together with the known speed of the wave through the substrate, to determine the precise location of the touch.

**[0006]** A transparent touch sensor, and specifically a touchscreen, is generally placed over a display device, such as cathode ray tube (CRT), liquid crystal display (LCD), plasma, electroluminescent, or other type of display. Alternatively, the touchscreen can be constructed directly on the front surface of the display device, so that the surface of the display device is touch sensitive. This latter construction is desirable because it eliminates a piece of glass or other material between the viewer and the display device, increasing the perceived display brightness and contrast ratio. Also, there are economic advantages in dispensing with an overlay glass and not having to modify the chassis of the display device to make room for the overlay glass.

**[0007]** The acoustic touchscreen comprises an acoustic substrate and transducers, which are elements that convert energy from one form to another. For example, a transmit transducer may receive a tone burst from associated electronic circuitry and then emit an acoustic wave across the substrate. A receive transducer may receive a transmitted acoustic wave from the substrate and generate an electronic signal that is transmitted to associated electronic circuitry for processing.

**[0008]** Various types of acoustic transducer assemblies are known. The most common types used in acoustic touchscreens are wedge transducer assemblies, grating transducer assemblies, and edge transducers.

**[0009]** FIG. **1**(*a*) illustrates a typical wedge transducer assembly **10***a*, which utilizes the phenomenon that acoustic waves are refracted when they are obliquely incident on a boundary surface of different media with appropriately differing wave velocities. Based on this principle, the wedge transducer assembly **10***a* consists of a plastic wedge **12** with its hypotenuse adhered to the front surface **18** of the acoustic substrate **16**, which is composed of a different material than that of the wedge **12**, e.g., glass. The wedge transducer assembly **10***a* also comprises a transducer, and specifically a piezoelectric element **14**, mounted to a side of the wedge **12** other than the hypotenuse. As illustrated by the arrows, the piezoelectric element **14** couples to a bulk wave in the wedge **12**, which propagates at the critical angle, i.e., the "wedge angle," to refract to or from a horizontally propagating wave in the substrate **16**.

**[0010]** FIG. **1**(*b*) illustrates a typical grating transducer assembly **10***b*, which comprises a grating **22** composed of perturbation elements **24**, which are aligned in parallel strips along front substrate surface **18**. The grating transducer assembly **10***b* also comprises a transducer, and specifically a piezoelectric element **26**, mounted on a rear surface **28** of the substrate **16** opposite the front substrate surface **18**. As illustrated by the arrows, the piezoelectric element **26** couples to a bulk wave in the substrate **16**. This bulk wave couples, via the grating **22**, to two oppositely traveling horizontally propagating waves in the substrate **18**. Further details regarding the structure and use of grating transducers are disclosed in U.S. Pat. No. 6,091,406, which is expressly incorporated herein by reference.

**[0011]** FIG. **1**(*c*) illustrates a typical edge transducer **10***c*, which comprises a piezoelectric element **32** mounted directly on an edge **34** of the substrate **16** in such a manner that an acoustic wave with appreciable power at the front substrate surface **18** is generated. The interface thus serves the mechanical function of connecting the piezoelectric element **32** to the substrate **16**, as well as the acoustic function of coupling to a horizontally propagating wave in the substrate **16**, as illustrated by the arrows. Further details regarding the structure and use of edge transducers to excite